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HISTORY AND PATTERNS OF BIRD-PLANE INTERACTIONS AT JFK INTERNATIONAL AIRPORT

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Abstract: The potential for bird-plane interactions is a major concern at John F. Kennedy International Airport (JFKIA), New York. Jamaica Bay Wildlife Refuge (JBWR), adjacent to JFKIA, attracts thousands of land and waterbirds and, in 1990, supported a Laughing Gull (*Larus atricilla*) colony in excess of 7,600 pairs. We examined the patterns of bird-plane interactions at JFKIA over an 11-year period (1980-1990). Numbers of bird-plane interactions generally increased over the 11-year study period. Gull species accounted for the majority of bird-plane interactions during this period, ranging from 58% to 90% of the total. Laughing Gulls comprised 34% of all bird-plane interactions. The majority of bird-plane interactions occurred from May to September, but peaked in June, July, and August. Laughing Gull adults, after-hatching-year, and hatching-year birds accounted for 60%, 16%, and 14%; respectively, of the total bird-plane interactions for the period April through November. Bird-plane interactions occurred on all runways of JFKIA although most occurred on the runway closest to the JBWR Laughing Gull colony. The numbers of bird-plane interactions at JFKIA could be reduced by reducing the number of nesting Laughing Gulls in JBWR and reducing the attractiveness of habitats to birds on and adjacent to the airport. JFKIA managers should work closely with other resource management professionals to accomplish these objectives.

Keywords: Gulls, *Larus spp.*, *Larus atricilla,* bird-plane interactions, airports

INTRODUCTION

The potential for collisions between birds and aircraft is increasingly a major concern at John F. Kennedy International Airport (JFKIA), New York. Much of this concern is focused at the bird populations at Jamaica Bay Wildlife Refuge (JBWR), a unit of Gateway National Recreation Area (GNRA) that is adjacent to JFKIA and administered by the National Park Service (NPS). The diverse habitats of the refuge attract thousands of water, land, and shorebirds and, in 1990, supported a Laughing Gull (*Larus atricilla*) nesting colony in excess of 7,600 pairs. It is the occurrence of this gull colony immediately adjacent to the airport, and of other bird species within JBWR, and their potential hazard to aircraft, that provided the impetus for this study.

In response to this concern, the NPS, in cooperation with the Port Authority of New York and New Jersey convened an expert panel in 1989 to review the bird hazard to aircraft at JFKIA (Buurma et al. 1989). While the panel recognized the extreme nature of the bird-strike hazard caused by the proximity of the colony to the airport, they concluded that the Laughing Gull colony could not be considered in isolation from hazards posed by other birds. Further, the panel found the airport to be an "attractive nuisance." This is because many landscape features on, and in the vicinity of, the airport also provide habitats that attract a variety of bird species. Further, the highly urbanized nature of western Long Island and relatively low availability of alternative habitats probably increase the use of the refuge and adjacent habitats by birds. This paper examines the history and patterns of bird-plane interactions at JFKIA between 1980 and 1990. Emphasis is placed on Laughing Gulls and other gull species due to their relatively high frequency of involvement in bird-plane interactions at the airport.

STUDY AREA

JFKIA is approximately 2,226 ha (5,500 ac) in size and is bounded on the west, north, and east by the borough of Queens, and on the south by Jamaica Bay. Although the airport is located on the highly urbanized western end of Long Island, there is a range of diverse habitats on and immediately surrounding the airport that attracts a variety of bird species. These include the runways and grass infield areas of the airport, the grassy areas along the Van Wyck Expressway, a major landfill (Edgemere), and extensive grass-covered areas of a golf course and race track (Aqueduct). These habitats include fresh and salt water marshes, open fields, golf courses, freshwater and brackish ponds, and sandy beaches.

METHODS

All birds found dead on or near the runways and taxiways of JFKIA between 1980 and 1990 were collected by personnel of the airport's Bird Dispersal Unit. Date, species, location found, and age were recorded as were sex and breeding status, when possible. In 1990, we considered a carcass a bird-strike if there was (1) evidence of severe physical trauma (e.g., extreme hemorrhaging, absence of internal organs, or internal organs malformed, damaged, or dislocated within the body cavity as not to have been caused by any other factor but high-speed, blunt-force trauma), or (2) loss of external body parts. These same criteria were applied for carcasses examined between 1980 and 1989. Additionally, bird-strike reports came from pilots; however, pilots were not always aware they hit birds. Further, pilot-reported bird strikes represented less than 10% of the total number of carcasses collected and identified as bird strikes between 1980 and 1990.

Unfortunately, bird-plane contact is sometimes difficult to quantify since some birds that are killed by jet-blast may sometimes meet the criteria we defined for a bird strike. Birds that are killed either by direct contact with aircraft or by jet-blast present a continuum of physical damage to carcasses. Therefore, it would be difficult to be 100% certain in separating all carcasses found into bird strike or jet-blast as cause of death. However, whether bird deaths at JFKIA are caused by actual contact with aircraft or by jet-blast; we consider both to be a threat to aircraft operations and public safety. In this paper, we refer to these two categories as bird-plane interactions.

Gull species were divided into five groups; Laughing (LAGU), Herring (*L. argentatus*, HERG), Ring-billed (*L. delawarensis*, RBGU), Great Black-backed

(L. marinus, GBBG), and unknown (UNGU) gulls. A sixth category (Other birds) was included for non-gull species. For some analyses, Herring, Ring-billed, Great Black-backed, and unknown gull species were combined into another category termed Other gulls. Age classes were divided into five groups; young of the year (HY), after hatching year or second year birds (AHY), birds not of adult breeding plumage that could not be specifically identified (IMM), birds with adult breeding plumage (ADT), and birds that were not able to be aged (UNKNOWN).

Laughing Gull colony size was estimated from helicopter surveys between 1979 and 1983 and were reported by Bucklcy and Gurien (1987). In 1984, 1985 (Buckley and Gurien 1987), and 1990 (Griffin and Hoopes 1991), Laughing Gull colony size and distribution was determined by censuses of all marsh islands adjacent to JFKIA in the eastern end of Jamaica Bay. Direct ground censuses were conducted using transects across each marsh island. Six to 15 people walked transects, and, in 1985 and 1990, each nest was marked with an individually numbered flag.

We examined correlations between total numbers of birds, Laughing Gulls, and Other gulls and numbers of plane operations at JFKIA (Sokal and Rohlf 1981). Similarly, the association between numbers of Laughing Gulls involved in bird-plane interactions and numbers of Laughing Gull nests in JBWR were also examined using correlation analysis.

RESULTS

Numbers of birds found dead and attributed to bird-plane interactions at JFKIA have generally increased between 1980 and 1990 (Table 1). Gull species accounted for the majority of carcasses recovered over this pe-

Table 1. Numbers of birds involved in bird-plane interactions at JFKIA, by species and year, 1980 - 1990.

Year	LAGU[a,b]	HERG	GBBG	RBGU	UNGU	All gulls	Other birds	Total
1980	19(11)	61(36)	14 (8)	13(8)	20(12)	127(74)	44(26)	171
1981	20(16)	45(37)	3 (2)	7(6)	5 (4)	80(65)	43(35)	123
1982	14 (9)	40(27)	7 (5)	10(6)	16(11)	87(58)	63(42)	150
1983	51(24)	55(26)	9 (4)	16(8)	17 (8)	148(70)	63(30)	211
1984	60(21)	68(24)	37(13)	20(7)	13 (5)	198(69)	91(32)	289
1985	86(22)	135(35)	24 (6)	13(3)	27 (7)	285(74)	102(26)	387
1986	60(40)	26(17)	5 (3)	9(6)	4 (3)	104(69)	47(31)	151
1987	135(54)	41(17)	12 (5)	9(4)	15 (6)	212(86)	36(15)	248
1988	180(48)	92(25)	52(14)	5(1)	6 (2)	335(90)	40(10)	375
1989	186(50)	108(29)	27 (7)	2(1)	9 (2)	332(90)	39(11)	371
1990	142(43)	80(24)	9 (3)	8(2)	1 (1)	240(72)	94(28)	334
Total	953(34)	751(27)	199 (7)	112(4)	133 (5)	2,148(77)	662(23)	2,810

[a]LAGU = Laughing Gull, HERG = Herring Gull, GBBG = Great Black-backed Gull, RBGU = Ring-billed Gull, UNGU = unknown gull.

[b] Percent total in parentheses. May not equal 100 due to rounding.

riod, ranging from 58% to 90 % of the carcasses recovered each year (Table 1). Laughing Gulls comprised 34% of all bird-plane interactions at JFKIA and exhibited the largest increase in numbers and percentages of carcasses recovered between 1980 and 1990 (Table 1). Herring Gulls were the next most frequent species involved in bird-plane interactions. Although numbers of Herring Gulls involved in bird-plane interactions fluctuated considerably during the 11-year period, they comprised a declining percentage of the total. Similarly, numbers of Great Black-backed Gulls involved in bird-plane interactions fluctuated greatly between years, but the percentages were relatively small in all years, as were the percentages of Ring-billed Gulls involved in bird-plane interactions (Table 1). Numbers of Other birds involved in bird-plane interactions have fluctuated between 1980 and 1990, as have the proportions of the total number of bird-plane interactions they represent. Further, there was a marked decline in number of bird-plane interactions for all species groups in 1986 (Table 1).

The Other birds category was comprised of passerines (6% of total), owls (5% of total), waterbirds (i.e., waterfowl, cormorants, and loons; 4% of total), wading birds (3% of total), and raptors (not including owls; 2% of total). Unidentified birds, shorebirds, terns, Black Skimmers (*Rynchops niger*), and Ring-necked Pheasants (*Phasianus colchicus*) each constituted ≤ 1% of the total number of bird-plane interactions. Between 1980 and 1990, total numbers of birds, Laughing Gulls, and Other gulls involved in bird-plane interactions at JFKIA were not significantly ($P > 0.05$) correlated with total numbers of aircraft operations (Table 2). However, numbers of Laughing Gulls involved in bird-plane interactions at JFKIA were significantly correlated with numbers of Laughing Gull nests in JBWR (Pearson's correlation, $r = 0.968$, $df = 6$, $P < 0.001$; Table 2).

Table 2. Numbers of Laughing Gulls involved in bird-plane interactions, numbers of Laughing Gull nests in Jamaica Bay Wildlife Refuge, and plane operations at JFKIA, 1979 - 1990.

Year	Number of Laughing Gulls Involved	Estimated Number of Laughing Gull Nests[a]	Total Number of Plane Operations[b]
1979	1	15[c]	ND[d]
1980	19	235	268,653
1981	20	325	251,672
1982	14	715	252,371
1983	51	1,805	262,696
1984	60	2,802	273,787
1985	86	2,741	254,736
1986	60	ND	249,647
1987	135	ND	259,532
1988	180	ND	279,908
1989	186	ND	208,356
1990	142	7,629[e]	283,748

[a] From Buckley and Gurien (1987) unless otherwise noted.
[b] Total does not include military flights.
[c] From Post and Reipe (1980).
[d] No data available.
[e] From Griffin and Hoopes (1991).

The majority of bird-plane interactions occurred from May to August, but peaked in June for Laughing Gulls and May for other gull species (Table 3). Numbers of birds found dead at JFKIA during summer (June - August) steadily increased since 1980 and varied considerably (Table 4). Generally, more bird deaths occurred in June ($\bar{x} = 56.9$), and there was a notable fluctuation in numbers of bird deaths in September between years (Table 4).

Adult gulls accounted for the majority (60%) of Laughing Gulls involved in bird-plane interactions, followed by AHY (16%) and HY (14%) age classes for April through November, the period when this species oc-

Table 3. Numbers of bird-plane interactions at JFKIA, by month and group, 1980 -1990.

Group	Month											
	J	F	M	A	M	J	J	A	S	O	N	D
LAGU[a]	0	0	0	3	46	435	270	159	36	3	1	0
Other gulls	62	42	76	117	221	130	59	111	120	84	100	73
Other birds	31	24	38	38	38	61	67	87	110	34	97	37
Totals	93	66	114	158	305	626	396	357	266	121	198	110

[a]LAGU = Laughing Gull

Table 4. Number of bird-plane interactions at JFKIA, June through September, 1980 - 1990.

Year	June	July	August	September
1980	24	8	16	11
1981	25	9	7	14
1982	21	5	18	13
1983	52	26	22	16
1984	43	34	47	44
1985	65	44	44	62
1986	48	12	18	3
1987	50	78	24	16
1988	101	64	47	44
1989	113	61	62	23
1990	84	55	52	20
Totals	626	396	357	266

curs at JFKIA (Table 5). However, during May, June, and July, adults and AHY birds accounted for the majority (89%) of bird-plane interactions (Table 5); while HY Laughing Gulls accounted for 62% of bird-plane interactions in August and September.

Carcasses from bird-plane interactions were encountered on all runways on JFKIA, with the plurality (37%) occurring on runway 13R/31L (Table 6). Laughing Gulls comprised the largest percentage (48%) of the bird-plane interactions on this runway and on runway 13L/31R (41%). Other gulls accounted for 38% of the total number of bird-plane interactions at JFKIA and comprised the majority (51%) of total number of bird-plane interactions on runway 4L/22R (Table 6). Other bird species accounted for 24% of all bird-plane interactions and for 35% of total bird-plane interactions on runway 4R/22L (Table 6).

DISCUSSION

Birds recovered dead on JFKIA could have died in several ways including: contact with aircraft, jet-blast, contact with a vehicle other than aircraft, or from natural causes (i.e., predation, disease). However, during nearly 700 h of observation at JFKIA in 1990, we observed 10 Laughing Gulls killed by actual contact with aircraft, one Laughing Gull apparently killed by jet-blast, and 15 - 20 birds that came so close to moving aircraft they were pushed away from, or narrowly avoided contact with aircraft. Upon examination of the 10 carcasses known to be bird strikes, we found one or both of the criteria we set in defining a carcass as resulting from a bird-plane interaction. Thus, we believe the numbers of interactions we report here, fairly represent the numbers of birds involved in bird-plane interactions that occurred at JFKIA during the study period, and exclude birds that died from causes not related to aircraft operations.

Much of the increase in numbers of bird-plane interactions at JFKIA between 1980

Table 5. Number of Laughing Gulls involved in bird-plane interactions at JFKIA, by age and month, 1980 - 1990.

Month	Hatching Year	After Hatching Year	Immature	Adult	Unknown	Total
April	0	1	0	2	0	3
May	0	20	2	24	0	46
June	0	83	28	295	29	435
July	9	35	8	214	4	270
August	103	9	2	31	14	159
September	18	6	1	3	8	36
October	0	0	0	0	3	3
November	0	0	0	0	1	1
Totals	130 (14)[a]	154 (16)	41 (4)	569 (60)	59 (6)	953

[a] Percentages are given in parentheses.

Table 6. Numbers of Laughing Gulls, Other gulls, Other birds, and Unknown gulls involved in bird-plane interactions at JFKIA, by runway, 1980 - 1990.

Species	Runway				Totals[a]
	13R/31L	13L/31R	4R/22L	4L/22R	
Laughing Gulls	494	102	131	221	948
Other gulls	325	43	236	452	1,056
Other birds	171	98	217	169	655
Unknown gulls	43	6	33	51	133
Totals	1,033	249	617	893	2,792[a]

[a] Does not include 18 birds that had no runway designation recorded. Thus, the total in this table does not equal the total in Table 1.

and 1990 is probably the result of corresponding increases in the numbers of gulls nesting in JBWR. This is supported by the significant correlation between numbers of Laughing Gull nests in JBWR, and numbers of Laughing Gulls involved in bird-plane interactions. The increased numbers of Laughing Gull nests is probably due to recruitment from within the colony as well as immigration of individuals into the JBWR colony from southern New Jersey colonies that have greatly expanded over the past 10 years (Andrews 1990). The between year fluctuations in numbers of Great Black-backed, Herring, and Laughing gulls involved in bird-plane interactions may be partly due to experimental and new management techniques implemented at JFKIA, such as tall-grass management on the airport (Buckley and Gurien 1987) and egg-oiling programs in the Jamaica Bay Laughing Gull colony (Griffin and Hoopes 1991). Although we believe these factors have contributed substantially to these fluctuations, we cannot eliminate the possibility that nest flooding,

varying food availability, and other environmental factors may also have affected the numbers of bird-plane interactions at JFKIA. We attribute the decrease in bird-plane interactions for all bird groups in 1986 to the closure of the Pennsylvania and Fountain Avenue landfills that were immediately adjacent to JFKIA. We believe closing of the landfills caused a reduction in food availability similar to that reported for gulls on Cape Cod, Massachusetts (Cavanagh and Griffin 1990).

The increased number of bird-plane interactions at JFKIA between May and August is most likely due to the initiation of nesting activity and the corresponding increase in bird activity on and around the airport. Further, JFKIA provides suitable loafing and foraging sites for gulls and is adjacent to several other sites that provide freshwater and additional foraging and loafing sites (Buckley and Gurien 1987, Griffin and Hoopes 1991). Gulls nesting in Jamaica Bay must fly over the airport to reach these sites, thereby increasing the potential for interactions with aircraft. We believe the increase in bird-plane interactions in September and November for Other birds is attributable to the migratory patterns of these species. The reason for the temporal differences by age in Laughing Gulls involved in bird-plane interactions is due to the chronology of the nesting season. Only adults and AHY birds were present from May to late July; however, in August and September, gull chicks hatched during that breeding season fledged and dispersed from the colony. Further, Laughing Gull colonies in New Jersey also produce HY birds that disperse northward into the Jamaica Bay area.

Bird carcasses were recovered from all runways at JFKIA between 1980 and 1990, with the majority being Laughing Gulls from runway 13R/31L. The reason for this high occurrence of birds found dead along this runway is two-fold. First, runway 13R/31L is the longest runway on JFKIA (4,442 m) and covers a major section of JFKIA from southeast to northwest. Secondly, the runway is between the JBWR Laughing Gull colony and several areas attractive to gulls on and adjacent to the airport. Thus, Laughing Gulls flying to these areas fly in a direct line over this runway (Griffin and Hoopes 1991). Further, Laughing Gulls flying toward the JBWR Laughing Gull colony in the evening fly well over 60 m in altitude, but as they approach the colony, they drop to between 0 and 10 m in altitude as they pass over runway 13R/31L (Griffin and Hoopes 1991). Finally, Laughing Gulls tend to flock in the evening as they fly low over the airport. Other gulls account for the majority of bird-plane interactions on runway 4L/22R, because there is a concrete apron around the end of the runway that provides a suitable loafing site for these species. Additionally, Herring Gulls were frequently observed dropping shellfish in this area.

CONCLUSIONS AND MANAGEMENT RECOMMENDATIONS

JFKIA has a serious problem with bird-plane interactions. Given the coastal location of JFKIA and the attractiveness of the various habitats on and around the airport to birds, bird-plane interactions will continue to be a problem at JFKIA. Gulls account for the majority of all bird-plane interactions. Laughing Gulls are one of four gull species that regularly occur at the airport and are present in the area for approximately six months each year; yet, they account for approximately half of all gulls involved in bird-plane interactions (40% to 54% since 1986). Most studies indicate that gulls pose the greatest threat to aircraft (Blokpoel 1976, Frings 1984) compared to all other threats (i.e., mechanical

failure, pilot error, bad weather conditions). Solman (1981) found 17 of 28 (61%) of the more serious bird strike incidents involving civilian aircraft at airports around the world since 1912 were caused by gulls. JFKIA is the twentieth busiest airport in the U.S., in terms of aircraft operations, but was first (by nearly 10 times) both in total number of bird-plane interactions and total number of bird-plane interactions per 10,000 operations (Griffin and Hoopes 1991).

The goal of managers at JFKIA is to reduce the number of bird-plane interactions. To achieve this goal, several actions are needed. First, there needs to be a reduction in the numbers of Laughing Gulls nesting in Jamaica Bay Wildlife Refuge. We believe that reducing the numbers of nesting Laughing Gulls would cause a decrease in the total number of Laughing Gulls flying over the airport, thereby reducing the potential for bird-plane interactions. Second, airport management must reduce the attractiveness of habitats on the airport to birds, such as eliminating low areas that fill with fresh water and reducing access to the sewage treatment plant (Griffin and Hoopes 1991). This would also potentially reduce the numbers of birds flying over, and found on, the airport. Finally, to reduce this complex resources management problem, much greater cooperation is needed between airport management and federal, state, and city resource management agencies, as well as interested private organizations.

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